

Original Article

Determining Tuffier's Line by Ultrasound in Pregnant and Non-pregnant Female Patients: a prospective cohort study

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Abstract:

Objectives: The correct determination of the vertebral level is important in anesthesia management and the prevention of possible risks. It has been shown that estimation of L4/5 intervertebral lumbar level based on Tuffier's line determined by palpation (palpated L4/5) is often inaccurate. In this study, it was aimed to investigate how Tuffier's line changes in the lateral decubitus position due to pregnancy. **Material and Methods:** The patients were divided into two groups in this prospective cohort study. The pregnant patients were assigned to Group P ($n = 75$) while the non-pregnant patients were assigned to Group NP ($n = 60$). Lumbar ultrasound was conducted in both groups in the left lateral decubitus position to verify the vertebral level determined by Tuffier's line that was detected by palpation. Demographic data, determination time of Tuffier's line, ultrasound, and the detected vertebral levels were recorded in both groups. **Results and Discussion:** Vertebral levels detected by both techniques were compatible with 35 (46.6%) patients in Group P and 36 (60%) patients in Group NP ($p = 0.165$). The vertebral levels in Group P detected via ultrasound were determined at L2 in three (4%) patients, at L2/3 in three (4%) patients, at L3 intervals in three (4%) patients, and at the L3/4 interval in 31 (41.3%) patients. The vertebral levels of the patients in Group NP detected via ultrasound was at L2/3 in 2 (3.3%) patients, and at the L3/4 interval in 22 (36.7%) patients. For the risk of insertion from a risky injection site, the OR = 3.96–95 and GA = 0.82–19.05 in Group P were higher compared to Group NP (approximately 4 times higher). While Group P was significantly limited in the risk analysis, according to L3 ($p = 0.087$), the risk under this level was similar ($p = 0.124$). In this study, the verification of Tuffier's line determined through palpation did not show the correct vertebral level in almost half of the patients in the lateral decubitus position, regardless of pregnancy and demographic data. **Conclusion:** We believe a possible spinal cord injury can be prevented by determining the needle insertion site via lumbar ultrasound in the pregnant patients.

Keywords: ultrasound; anesthesia in obstetrics; anatomy

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Introduction:

Tuffier's line has been used as an anatomical landmark in the estimation of the vertebral levels via palpation for neuraxial anesthesia for a long time¹. The target point for the Tuffier's line is considered to be the L4 spinous process or the L4/5 intervertebral

space. The correct determination of the location of Tuffier's line is a particularly important issue for the safety of patients.

Spinal anesthesia is often preferred in cesarean section operations. It is important to select the appropriate intervertebral area during needle insertion

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to prevent spinal cord damage². Ultrasound, which is a non-invasive method with no radiation danger, has increasingly been used for the determination of the correct vertebral level in obstetric anesthesia among anesthetists³.

Recent studies have demonstrated that Tuffier's line presents at an accuracy ranging from 30% to 70% in varied populations, including both elderly and pregnant patients. This rate is 55%–76% in non-pregnant women⁴. The multiple variations of lumbar space identification may be due to variations in body structure, height, and body mass index (BMI) of people with different ethnic origins⁵. Physiological changes, such as hyperlordosis, increased body weight, and the rotation of the spinal canal around the long axis, in term pregnant women, may cause differences in Tuffier's line, as determined via palpation³. In studies comparing Tuffier's line in obese (BMI ≥ 30 kg/m²) and non-obese (BMI < 30 kg/m²) pregnant patients in the sitting position, Tuffier's line was more cephalic in the obese group^{6,7}.

Patients with a smaller abdominal circumference, lower BMI, and younger patients have intervertebral levels lower than the palpated level in the left decubitus position⁸. In the only study comparing pregnant and non-pregnant women in the left lateral decubitus position, it emphasized that even the pregnant Korean group had BMI values of 25.8 kg/m² and this rate was lower than the western population³.

The aim of this study was to investigate the difference between pregnancy-related vertebral levels of the Tuffier's line palpated in the lateral decubitus position within our population.

Materials and Methods:

This prospective study was conducted between January and May 2017 at the Department of Gynecology and Obstetrics Outpatient Clinic (for patients who applied for polyclinic control) and the Operating Room of Gaziantep University Sahinbey Research and Application Hospital. Approval for this study was provided by the Ethics Committee of the Faculty of Medicine, Gaziantep University. Prior to beginning the study, informed consents were provided by all patients. There were 60 non-pregnant and 75 pregnant women who had a gestational week of 36 and 40 weeks. Participants included in this study were aged between 18 and 45 years and were in the I–II risk group according to the classification of American Society of Anesthesiologists (ASA) in the pre-anesthesia assessment. Lumbar ultrasound

was conducted in the operating room on 35 pregnant women and at the Gynecology and Obstetrics outpatient clinic on 40 pregnant women. The patients included in the study were divided into two groups, pregnant women (Group P) and non-pregnant and volunteers (Group NP).

Those patients with a spinal deformity, previous spinal surgery, shorter than 150 cm in height or taller than 180 cm in height, had difficulty in positioning, had to be taken to an urgent surgery, or did not want to participate in the study, were excluded. In the study, whole spinal ultrasonography and examinations via palpation were conducted by a research assistant (BS) with three years of experience.

We recorded data on age, body weight, height, abdominal circumference, BMI, ASA score, and surgical indication. Additionally, we recorded data on Tuffier's line vertebral level (TL-p) detected via palpation, Tuffier's line vertebral level (TL-us) detected via ultrasound, Tuffier's line detection times, as well as gravidity, parity, and the gestational week in pregnant patients.

After the patients were placed on the operating table, the head, knees, and hips were brought to maximum flexion in the left lateral decubitus position, and the apices of the right and left iliac crests were palpated. The intercrystalline line (Tuffier's line), combining the two points, was then detected. The vertebral level detected via palpation was marked as Tuffier's line. The transition of the line from the spinous process was defined as L4, and the transition from the intervertebral interval was defined as the L4/5 intervertebral interval. The patient's position was maintained, and the patient was then scanned using a low-frequency (2–5 Hz) convex probe from an Esaote MyLab30 ultrasound scanner. The scan was located 1–2 cm lateral of the spinous process (paramedian sagittal plane) on the lower region of the back and the orientation indicator was placed to show the patient's head. The sacrum was viewed in the front as a flat hyperechoic structure with a large acoustic shadow. By slightly sliding the ultrasound probe upwards, the L5–S1 interval was determined. The probe was then shifted upwards and the L4/5, L3/4, L2/3, and L1/2 intervertebral intervals were counted and marked. Tuffier's line determined via palpation and the vertebral level determined with ultrasound were compared and recorded.

Statistics

The Shapiro-Wilk test was used to test the

compatibility of quantitative data to a normal distribution. Student's *t*-tests were used for the comparisons of variables that were consistent with normal distributions in both groups, while Mann-Whitney U tests were used for non-normal distributions. Correlations between categorical variables were tested using chi-square tests. The confidence interval was regarded as 95%. The SPSS 22.0 package program was used for all analyses. A *p* level of < 0.05 was regarded as significant.

Power analysis: The prevalence for the healthy non-obese group for L4 or L4/5 was obtained from a study by Ozturk et al., (9) as approximately 60% and 30% with changes based on clinical experience. Although the minimum required total sample size was calculated as 98 to increase the power of the study, the total sample size was increased to 135 ($\alpha = 0.05, 1 - \beta = 0.80$). G-Power 3.1.9.2 software was used for the power analysis.

Ethical clearance:

This study was approved by the Gaziantep Medical University Ethics Committee and the written informed consent of each participant included in the study was obtained before any data were coll

Results:

Table 1 shows the demographic data of the patients. The groups were similar in terms of age, height, gravidity, and parity ($p > 0.05$). There was a significant difference between the groups in terms of weight, BMI, and abdominal circumference ($p < 0.001$).

Table 1. Demographic data

	Group P (n=75)	Group NP (n=60)	<i>p</i>
Age (year)	30.45 ± 5.36	29.08 ± 6.46	0.180
Height (cm):	163 ± 7.01	1.62 ± 5.02	0.905
Weight (kg)	78.53 ± 10.19	66.21 ± 12.7	0.001*
BMI	29.58 ± 3.87	25.08 ± 5.09	0.001*
Gravidity	3.13 ± 1.72	2.65 ± 1.23	0.216
Parity	1.71 ± 1.31	2.04 ± 0.88	0.252
Gestational week	37.30 ± 1.15	(-)	
Abdominal circumference	104.79 ± 11.22	78.97 ± 11.92	0.001*
tP (min)	5 ± 1.63	4.43 ± 1.45	0.037*
tUS (min)	46.81 ± 14.11	43.52 ± 10.55	0.135

*statistically significant at the level of $p < 0.05$

tP: Determination time of Tuffier's line via palpation

tUS: Determination time of Tuffier's line via ultrasound

The determination time (tP) of Tuffier's line via palpation was 5 ± 1.63 seconds in Group P and 4.43 ± 1.45 seconds in Group NP. When the groups were compared in terms of tP, Group P took significantly longer ($p = 0.037$). The tP of Tuffier's line via ultrasound (tUS) was 46.81 ± 14.11 seconds in Group P and 43.52 ± 10.55 seconds in Group NP. When the groups were compared in terms of tUS, no significant difference was found between the groups ($p = 0.135$).

The vertebral level determined via palpation was 58.7% in L4/5 and 41.3% in L4 in Group P, and 63.3% in L4/5 and 36.7% in L4 in Group NP. Both groups were similar in terms of the vertebral levels detected via the palpation technique ($p = 0.581$).

The vertebral levels in Group P detected via ultrasound, whose vertebral level was L4, as determined via palpation, were determined at L2 in three (4%) patients and at L3 intervals in three (4%) patients. The vertebral level detected via ultrasound in Group P was similar in 25 (33.3%) patients as L4. The vertebral levels of the patients in Group NP, whose vertebral level was L4 as determined via palpation, were not determined at L2 and L3 intervals in any of the patients via ultrasound. The vertebral level detected by ultrasound in Group NP was also similar in 22 (36.7%) patients as L4 ($p = 0.100$; Figure 1).

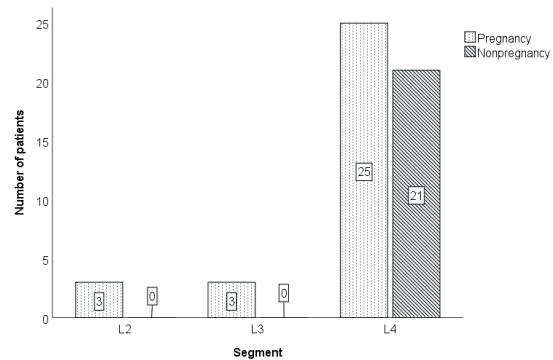


Figure 1. Intervertebral level of palpated L4 evaluated by ultrasonography

The vertebral levels of the patients in Group P detected via ultrasound, whose vertebral level was L4/5 as determined via palpation, was at the L2/3 interval in three (4%) patients and at the L3/4 interval in 31 (41.3%) patients. The vertebral level detected by ultrasound in Group P was similar in 10

(13.4%) patients as L4/5. The vertebral levels of the patients in Group NP detected via ultrasound, whose vertebral level was at L4/5 level, as determined via palpation, was at L2/3 in 2 (3.3%) patients, at L3/4 in 22 (36.7%) patients, and at the L3/4 interval in 22 (36.7%) patients. The vertebral level detected by ultrasound in Group NP was similar in 14 (23.3%) patients as L4/5. Both groups were similar in terms of the vertebral levels detected via ultrasound ($p = 0.100$; Figure 2).

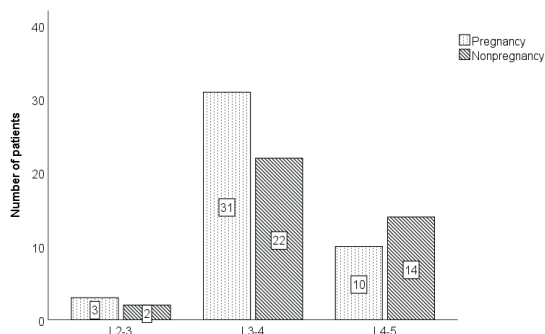


Figure 2. Intervertebral level of palpated L4/5 evaluated by ultrasonography

The same vertebral level was found in 35 (46.6%) patients in Group P and 36 (60%) patients in Group NP by using both palpation and ultrasound techniques ($p = 0.165$). When the consistency of the methods between the Tuffier’s line vertebral levels determined via ultrasound and palpation was compared, no significant difference was observed between the lumbar vertebral areas in Group P (ICC = -0.32, $p = 0.608$) and Group NP (ICC = -0.159, $p = 0.889$).

Table 2. Risk of spinal cord injury

Risk of Spinal Cord Injury	Total	Group P (n=75)	Group NP (n=60)	OR [95%CI]	p
Risk 1 (when spinal cord terminates at L3)					
Risk (+) n (%)	11 (8.1%)	9 (12.0%)	2 (3.3%)	3.96[0.82-19.05]	0.087
Risk (-) n (%)	124 (91.9%)	66 (88.0%)	58 (96.7%)	1(reference)	
Risk 2 (when spinal cord terminates at L3/4)					
Risk (+) n (%)	64 (47.4%)	40 (53.3%)	24 (40.0%)	1.71[0.86-3.41]	0.124
Risk (-) n (%)	71 (52.6%)	35 (46.7%)	36 (60.0%)	1(reference)	

*statistically significant at the level of $p < 0.05$

OR: Odds ratio, CI: Confidence Interval.

Comparison of misclassification between Group P and Group NP

Risk 1: Termination of the spinal cord at the L3 level was accepted as a risk of developing a spinal cord injury.

For the risk of insertion from a risky injection site, the OR = 3.96–95 and GA = 0.82–19.05 in Group P were higher compared to Group NP (approximately 4 times higher). This risk coefficient was significant in Group P at the boundary ($p = 0.087$).

Risk 2: Termination of the spinal cord at the L1 level was accepted as a risk of developing a spinal cord injury.

For the risk of insertion from a risky injection site, the OR = 1.71–95 and GA = 0.86–3.41 in Group P was similar when compared to Group NP. This risk coefficient was not significantly different ($p = 0.124$; Table 2).

Examination of the factors affecting the risk of misclassification

The importance of age, height, weight, BMI, tP, gravidity, parity, abdominal circumference, and gestational week were not significant in the risk of misclassification ($p > 0.05$; Table 2).

Discussion:

Tuffier’s line is determined by palpation of anatomical marking points for a needle insertion site in traditionally applied and widely accepted methods. A false determination of the puncture level is a known risk factor for a conus medullaris injury in central neuraxial blocks. Thus, determining the correct identification of interspinous levels is

important in preventing neurological damage and the development of complications¹⁰.

There may be delays in completion of the neuraxial procedure when preprocedural ultrasound is used, so its routine use in obstetric anesthesia, where timely performance may be of vital importance, has not been preferred by clinicians in the past. Preprocedural ultrasound provides limited benefit in patients whose neuraxial procedure is predicted to be easy for a first-attempt success. However, an increase of approximately 1 minute in total time taken to set up the procedure with ultrasound is unlikely to be significant clinically. In patients in whom the neuraxial procedure is predicted to be difficult, a first attempt success rate with preprocedural ultrasound was not associated with an increased time to perform the procedure¹¹. In the present study, the average tP was 47 seconds in pregnant women and 43 seconds in the non-pregnant women.

In this study, the consistencies of the lumbar ultrasound method to determine verification of the vertebral levels, which were estimated by palpation in all patients in the left lateral decubitus position, were compared. We aimed to discover whether the results were affected by demographic data and pregnancy status of the patients.

Locks et al.,¹² conducted a study in which the L3/4 intervertebral cavity in the sitting position was estimated by palpation in 90 pregnant women, including 43 obese and 47 non-obese patients who had a planned regional anesthesia for caesarean section. When the levels determined by ultrasound were verified, the accuracy was only 53% for non-obese patients and 49% for obese patients. In the current study, vertebral levels detected by palpation and ultrasound were compatible in 35 (46.6%) patients in the pregnant group and 36 (60%) patients in the non-pregnant group. Among both groups, the tP of Tuffier's line via palpation was longer in the pregnant patients ($p = 0.037$). The tP of Tuffier's line via ultrasound was similar in both groups ($p = 0.135$).

Margarido et al.,¹³ conducted a study on 45 full-term pregnant women and measured their vertebral levels via Tuffier's line by ultrasound in the sitting position and reported average vertebral levels were more cephalic, in the L2/3 intervertebral interval compared to non-pregnant women. Tuffier's line determined via palpation was on the cephalic side of the L4/5 intervertebral interval in all women. In the present study, the Tuffier's line of pregnant and non-pregnant

patients was more cephalic, but no significant correlation was found between the vertebral levels detected by palpation and ultrasound or with pregnancy ($p = 0.581$, $p = 0.100$, respectively). The fact that our measurements were performed in the lateral decubitus position may have played a role in having similar groups.

It has been stated that Tuffier's line determined by palpation is 0.7 in men and is more cephalic, up to the 1.0 level in women¹⁴. In non-pregnant patients, Chakraverty et al., compared the consistency between palpated and scanned intercrystalline lines. They revealed that the palpable intercrystalline lines in 88% of cases were one or more levels higher than the radiological intercrystalline line¹⁵. In another study, Whitty et al., observed that the levels determined by palpation were one or two levels higher than desired via ultrasound in defining the lumbar interspinous level and the location of the cavity. The researchers reported that the determination of the needle insertion site via palpation often causes erroneous results⁴. The concordance rate of L3/4 intervertebral lumbar level estimation between palpation and ultrasonography is reportedly 64% (6) in the general population and 36.4%⁷ in an obstetric population. Furthermore, the palpated intercrystal line tends to be more cephalad rather than caudal in obstetric populations^{8,9}. Hosokawa et al., reported that the accuracy rate of palpated L3/4 intervertebral lumbar level in pregnant women included in their study was 69.8%¹⁶. In the current study, Tuffier's line vertebral level was determined via ultrasound and was one or more levels above the vertebral level determined via palpation in 40/75 (53.3%) pregnant patients and 24/60 (40%) non-pregnant patients. Additionally, the vertebral level, where Tuffier's line passes, was in the L3/4 intervertebral interval in 41.3% in the pregnant group and 36.7% in the non-pregnant group.

When Srinivasan et al.,² compared the vertebral levels cut by Tuffier's line that were palpated in women via ultrasound, they stated they were located more cephalic. The average vertebral level of Tuffier's line detected via ultrasound was at the lower level of the L4 vertebra in non-pregnant women, and the lower level of L3 vertebra in pregnant women. In the obstetric population, 32%–48.5% of neuraxial blocks occurred at a more cephalic level (L1 is as high as L2). In 4%–20% of the cases, a needle insertion at L2/3 may cause a conus medullaris lesion. Via the ultrasound technique, Tuffier's line was determined at the L2 level in three patients, the L2/3 in three

patients, and at the L3 level in three patients in Group P, while in Group NP, it was at the L2/3 level in two patients. In the remaining Group NP patients, the vertebral level for Tuffier's line was at the L3/4, L4, and L4/5 intervals.

To avoid spinal cord trauma during lumbar puncture or neuraxial anesthesia, the needle insertion should be done below the spinal cord level¹⁰. The L2/3 interspace identified using Tuffier's line is usually higher than the actual L2/3 interspace¹⁷. In the present study, when it was considered that the spinal cord terminated at the L3 level, nine pregnant women were at a four times greater risk than two non-pregnant women ($p = 0.087$). Under the L3 level, this risk was similar between both groups ($p = 0.124$).

Kim et al.,³ investigated the accuracy of Tuffier's line with ultrasound in pregnant and non-pregnant patients in the left lateral decubitus position and stated that this line was more cephalic in pregnant women. It was emphasized that these pregnancy-related (68.2 ± 6.8 kg and 25.8 ± 2.4 kg/m², weight and BMI, respectively) and non-pregnancy-related (56.4 ± 7.2 kg and 21.7 ± 2.8 kg/m², weight and BMI, respectively) values are compatible with Asian society and are lower than those reported from western societies. When compared with our study, Group NP (66.21 ± 12.7 kg and 25.08 ± 5.09 kg/m², weight and BMI, respectively) contained similar values as pregnant patients in their study. In Group P (78.53 ± 10.19 kg and 29.58 ± 3.87 kg/m², weight and BMI, respectively), these values were higher than in their study. In the correlation analysis, the BMI values of our study were similar between the groups.

Ozturk et al.,⁹ compared the accuracy of two different landmark methods via ultrasound and found no correlation between accuracy and demographic data (age, BMI, and sex). We also found, no difference in

terms of age, BMI, tP, gravidity, parity, abdominal circumference, or gestational week.

In the present study that examined Tuffier's line vertebral levels with palpation and ultrasound techniques in the lateral decubitus position, the results were similar in pregnant and non-pregnant groups. Our results suggest that Tuffier's line was in the L4 or L4/5 intervals in almost half of patients who had a lumbar ultrasound.

Conclusion:

It was determined that Tuffier's line did not show the correct vertebral level in almost half of the patients, independent of pregnancy status and demographic data. It is thought that central neuraxial blockage performed by determining the appropriate intervertebral interval via lumbar ultrasound is more successful and safer. Consequently, we recommend choosing a caudate level of the intervertebral space, which is palpated on Tuffier's line in pregnant women, for needle insertion in terms of patient safety.

Limitations

The limitation of this study is that all the patients were from the same sex and age group. We believe that performing a lumbar ultrasound will increase our knowledge and decrease possible spinal injuries in a larger patient group.

Competing interests

There is no competing interests.

Funding

There is no funding.

Authors's contribution

Data gathering and idea owner of this study: LP, BS, EM; Study design: LP, BS, EM, YE; Data gathering: BS, YE; Writing and submitting manuscript: LP, EM; Editing and approval of final draft: LP, EM

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